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CONTROL OF CYCLAMEN AND BROAD MITES ON GERBERA

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INTRODUCTION

The cyclamen mite (*Tarsonemus pallidus* Banks), has been one of the most destructive pests of the gerbera or Transvaal daisy (*Gerbera jamesoni* Bolus) when this is grown as a greenhouse floral crop. The economic losses are due not only to the actual crop damage resulting from the feeding of the mites but also to the money and labor wasted in ineffective efforts that florists have expended toward control. The broad mite (*T. latus* Banks) also often causes severe damage to gerbera and is sometimes associated with the cyclamen mite.

As one phase of the investigation on the tarsonemid mites, a study was made from 1933 to 1937, inclusive, of the mite injury and the problem of control on gerbera with particular reference to adaptation of treatments to the culture of the crop.

CULTURE OF GERBERAS AS A GREENHOUSE CROP

In recent years gerberas have become a widely-grown greenhouse crop whose flowers are in increasing demand. The showy, daisy-shaped flowers measure in some cases over 4 inches across, and the colors of the rays are in many shades of yellow, orange, pink, and red. The cut flowers, on 15- to 18-inch stems, retain their freshness longer

[1] The writer is indebted to F. J. Spruijt and F. S. Blanton for their cooperation in conducting experimental tests and caring for treated plants in the laboratory greenhouse at Babylon, N. Y., and to W. B. Wood for aiding in the vapor-heat treatments conducted at Washington, D. C., and, among the several florists, to V. A. Frank, Washington, D. C., to A. H. Bopp, Cumberland, Md., and especially to C. J. Van Bourgondien, Babylon, N. Y., who cooperated to the fullest extent in carrying out the experimental work at their respective establishments. Thanks are due to Freeman Weiss, of the Bureau of Plant Industry, for his cooperation in this work.

than most other cut flowers, and this quality added to the gerbera's productiveness makes it deserving of the popularity it is receiving. The number of plants grown by individual florists ranges from a few hundred to 60,000 or more.

Plants grown from seeds vary decidedly in form or color and abundance of flowers, type and ruggedness of growth, and susceptibility to diseases and pests. The seedlings are usually grown to the flowering stage in pots or the greenhouse bench, when the inferior ones may be recognized and discarded. Each of the selected seedlings may be divided annually into three to five plants, and in this manner stocks of uniform types may be built up and given varietal names. The plants are usually grown in raised ground benches, and, after they have flowered continuously from early in the fall until spring, they are divided and reset during June and July. The culture during the remainder of the year is similar to that given carnations except possibly for the provision of a slightly higher temperature.

Certain growers have progressed far in the development of many superior varieties. Too little time has elapsed, however, for the building up of these stocks to sufficient numbers to supply the general growers' demand. Because of this fact many florists are not culling out all the inferior seedlings and are growing many plants of rather poor quality. The pest problems are serious on the latter types as well as on the improved selections.

PESTS OF GERBERAS AND THE USUAL CONTROL PRACTICES

After the period of reestablishment, following the transplanting of the stock and of growth after the flowering period, the foliage becomes very dense. Under these conditions it is difficult to make thorough applications of insecticides to control the several pests attacking the foliage and flowers. Certain of these pests, including the whitefly *Trialeurodes vaporariorum* (Westw.), the aphid *Myzus persicae* (Sulz.), the thrips *Hercinothrips femoralis* (Reut.), *Thrips tabaci* Lind., and *T. nigropilosus* Uzel, and the common red spider, *Tetranychus telarius* (L.), are usually held in check by syringing, by fumigation with calcium cyanide, or by spraying with various materials. During the summer months, when the plants are becoming reestablished and the foliage is less dense, the growers attempt so to reduce these pests that they can be held in check during the remainder of the season. A leaf miner, *Agromyza pusilla* Meig., is at present combated by picking and destroying infested leaves, or by spraying with derris or nicotine extracts. This leaf miner is at times heavily parasitized by *Derostenus variipes* Cwfd. In contrast with their relatively successful control of the above-mentioned pests obtained by one or more of the methods employed, the florists have failed to control the cyclamen mite by these or other treatments.

Growers have usually mistaken the distinctive injury by the broad mite for a disease or cultural trouble, and therefore effective control measures against the real cause have usually not been applied.

Several other species of *Tarsonemus* mites have been found associated with both the cyclamen mite and the broad mite on foliage of gerberas, but are more frequently found on dying or dead foliage, or on foliage injured by thrips or the red spider. Judging from

laboratory experiments, these mites do not feed on healthy plant tissue and cause no primary plant injury. Instead they apparently feed on the fungi or other organisms associated with the decay of the plant tissue, or on the products of decay. From the standpoint of the grower, therefore, these saprozoic species may be ignored.

INJURY BY THE MITES

Because the mites attacking gerberas are so small, their presence is usually recognized by the plant injury rather than by finding the mites themselves. Both the broad mite and the cyclamen mite injure gerberas by feeding on the young foliage and flower parts. The

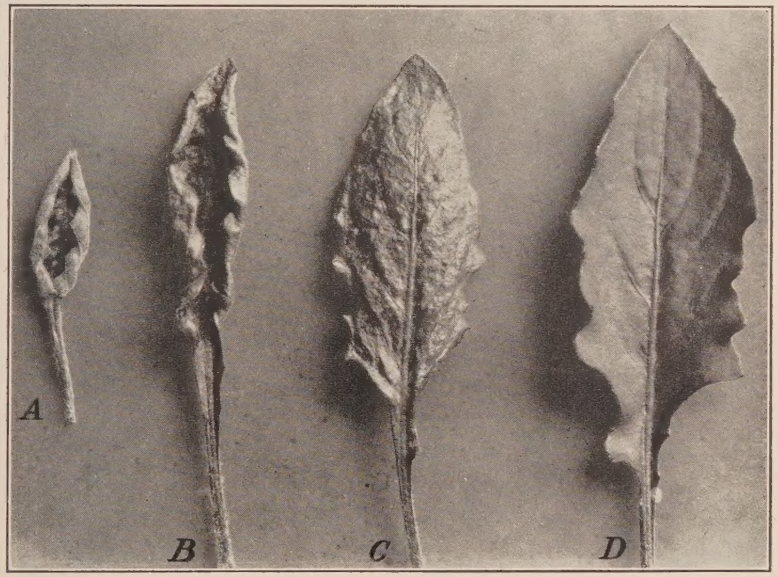

FIGURE 1.—Injury on gerbera foliage by the broad mite: *A* and *B*, Leaves fed upon on the upper surface while very young, resulting in upward curling; *C*, leaf injured on lower surface when more mature, which caused downward cupping; *D*, normal leaf.

injured areas on the lower leaf surface become bronzed, and injured flowers have part or all of the rays distorted and decolorized.

Although the broad mite occurs less frequently on the gerbera than on other plants, this species, when once established, causes very severe injury to both leaves and flowers. Because this mite reproduces very rapidly and builds up to large numbers within a short time, especially at high temperatures, all young leaves and flowers appear to be suddenly and severely injured. On the partly expanded foliage the mites feed over the entire lower leaf surface which takes on a uniformly dirty-bronze color with glazed appearance. Such leaves are readily recognized from above by the dull greasy green color and the slight crinkling and cupping downward (fig. 1, *C*). On very young leaves the broad mite is unable to penetrate the dense pubescence and feed

on the lower surface; but it injures the upper surface, causing a marked dwarfing and an upward curling (fig. 1, *A*, *B*). The mites swarm onto the young flower buds and by feeding on the juices of the young, developing rays prevent or greatly retard their development, leaving the flowers an entire loss (fig. 2).

FIGURE 2.—Gerbera flowers with rays decolorized and malformed by feeding of the broad mite.

The cyclamen mite is able to work down into the crown among the dense pubescence on the young leaves, where it feeds on the lower leaf surface, particularly along the veins. Injury usually consists of small bronzed areas along the midrib or of spots between the lateral veins

FIGURE 3.—Two gerbera flowers with rays injured by feeding of the cyclamen mite compared with normal flower on right.

which are visible on the lower surface but not noticeable from above. Such injury causes the leaves to roll slightly downward and thus affords further protection to the mites as the leaves reach maturity. The injury from both species is similar in nature, but that caused

by the cyclamen mite is usually less extensive and less conspicuous on the foliage. The cyclamen mite breeds more slowly than the broad mite and in all observed instances has been less abundant on gerbera.

The cyclamen mite also moves to the young flower buds and feeds beneath the bracts and on the young rays, preventing the normal expansion of the latter. It makes little difference whether few or many rays on a flower are distorted or stunted by this mite (fig. 3), for the destruction of only one or two rays renders the flower unsalable or of low market value.

A comparison of the injury by the two mites indicates that the broad mite causes more serious injury to the whole plant, particularly in warm greenhouses from late in the spring until early in the fall. During the cooler parts of the year it breeds very slowly and so causes little or no damage during the winter. On the other hand the cyclamen mite breeds during the cooler parts of the year and causes damage throughout the flowering season of the gerbera. The presence of the cyclamen mite is usually not detected until the injury appears on the flower. Since this is the marketable part of the gerbera crop, the cyclamen mite is undoubtedly the more serious economically. It is also the more serious pest because the usual practices fail to control it.

CONTROL OF THE BROAD MITE

Experiments [2] have shown that the broad mite is readily killed by dusting the plants with finely ground flowers of sulphur or colloidal sulphur, or with prepared dusts containing as little as 25 percent of sulphur and as much as 75 percent of inert carrier. This mite is also killed by certain other methods, including fumigations with calcium cyanide or naphthalene, and by the heat treatment which is used for control of the cyclamen mite. These other methods are not recommended as a control measure for the broad mite on gerberas because the low cost and effectiveness of sulphur make that the more economical material and because of the high tolerance of the host to sulphur dust.

Although the mites in either the egg stage or the quiescent stage ("pupae") are only slightly affected by sulphur, the larvae or adults emerging from these stages succumb shortly if sulphur is still present on the plants. Therefore only one dusting with sulphur, if not syringed off the plant within 4 or 5 days, will ordinarily destroy an infestation. In practical tests on gerbera, however, two or three applications were usually made at 5-day intervals to insure that all infested parts were reached by the dust or its vapors and the infestation destroyed. Where infestations occur, applications repeated two or three times are recommended as a general greenhouse practice.

CONTROL OF THE CYCLAMEN MITE

Florists generally recognize the presence of the cyclamen mite by its injury, but the mites (fig. 4) secrete themselves in the many crevices in the crown, young foliage, and flower parts, and few are reached

[2] SMITH, FLOYD F. CONTROL EXPERIMENTS ON CERTAIN TARSONEMUS MITES ON ORNAMENTALS. Jour. Econ. Ent. 28: 91–98. 1935.

by applications of sprays or dusts. Such fumigants as calcium cyanide, nicotine preparations, and naphthalene have not proved successful as control material because of the inacessibility of the cyclamen mite and its great resistance to these chemicals. Because the desirable varieties of gerberas are propagated vegetatively (by division of crowns), the infested plants are not discarded but are carried from year to year and are not freed of the cyclamen mite in the regular handling of the crop.

HOT-WATER TREATMENT

On the basis of experiments with heat treatments as a control for the cyclamen mite,[3] gerbera growers were advised to immerse their

FIGURE 4.—The cyclamen mite in its several stages as it occurs in crevices among flower parts of gerbera

plants in water at 110° F. for 15 or 20 minutes, but in two instances reports of incomplete control were received. Investigations of the methods employed in each case indicated that subsequent to treatment the plants were satisfactorily handled to prevent reinfestation, but in the treatment itself the plants were closely packed in a slatted crate such as is used for shipping lily bulbs, for immersion in water already heated by steam to 111° F. at the beginning of treatment. It appeared that the closely packed foliage would not permit rapid enough penetration of hot water to kill the mites during the period allowed.

[3] SMITH, FLOYD F. THE CYCLAMEN MITE AND THE BROAD MITE AND THEIR CONTROL. U. S. Dept. Agr. Cir. 301, 14 pp., illus. 1933.

Thermocouple readings made in crowded parts of the crated plants during their immersion showed that the temperature increased very unevenly during the 15-minute treatment. In one of three series where the plants were very closely packed in the box, the temperature among the crowns was 106° at the end of 5 minutes, 108° in 10 minutes, and 109° at the end of 15 minutes. In two other series a temperature of 110° was attained in 5 to 6 minutes. Figure 5 shows the temperatures as averaged for the three series to have been 108.3° at the end of 5 minutes and 109.5° at the end of 10 and 15 minutes of immersion. These records reveal the fact that the water temperature among closely packed plants increases irregularly to the point lethal

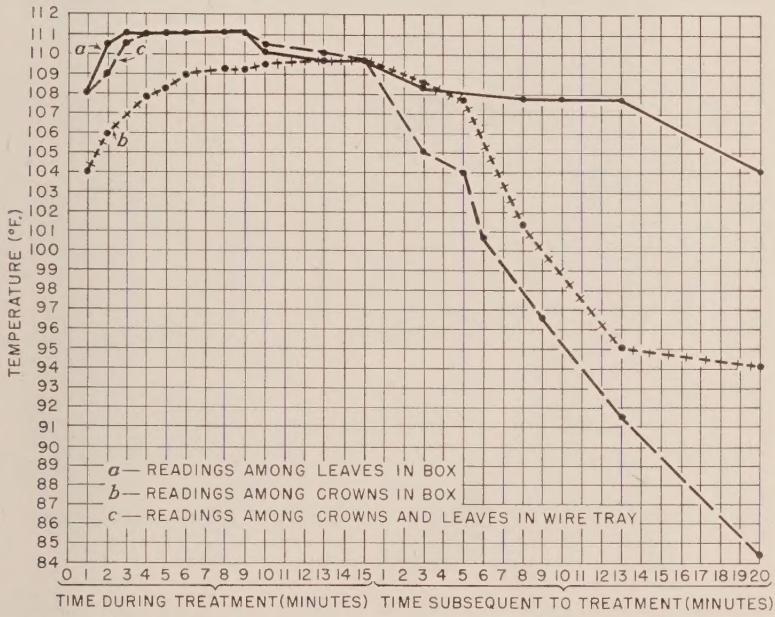

FIGURE 5.—Temperature changes occurring among gerbera plants during immersion in water at 111° F. and also during period following removal from the bath when packed in masses in crates (*a* and *b*) or in thin layers in a screen tray (*c*).

to the mites and seem to account for the fact that all mites were not being killed. Readings (fig. 5) taken after the plants were removed from the bath showed that in certain cases the temperature decreased very slowly among the leaves, and this probably accounted for an increased amount of plant injury (fig. 6).

The preferred treatments would permit rapid and even penetration of hot water to all parts of the plant occupied by the mites during treatment, then rapid cooling subsequent to treatment, to reduce plant injury. To meet these requirements a pipe-frame tray was made, covered with wire of ½-inch mesh and equipped with hinged lid, pulleys, and rope, so that it could be lowered into and raised from an 800-gallon vat of water (fig. 7). As many as 600 plants can be

spread out in a shallow layer in this tray without packing the foliage, and this will prevent the uneven penetration of the heat during treatment. As shown in figure 5 *c*, a temperature of 110° F. was reached

FIGURE 6.—Normal gerbera leaf (*A*) compared with one from plant injured by treatment in hot water (*B*). The treated leaf shows necrotic brown areas on each side of the midvein.

between 2 and 3 minutes after beginning treatment, among both crowns and leaves; and the temperature decreased more rapidly after treatment than it did in the treatments in crates (fig. 5, *a* and *b*).

Results of tests to determine the length of the hot-water treatment required to kill the mites on plants in the wire-mesh tray are given in table 1. A high percentage of mites was killed by a 10-minute immersion and a complete kill was obtained by an immersion of 15 minutes or longer. The mites that survived the 10-minute immersion were located in pubescence and in folds of young leaves or beneath bracts in flowers, whereas those in similar locations were killed by the 15-minute treatment. Because of injury to certain varieties of gerberas resulting from longer immersion, as discussed later, it is not advisable to treat them for more than 20 minutes.

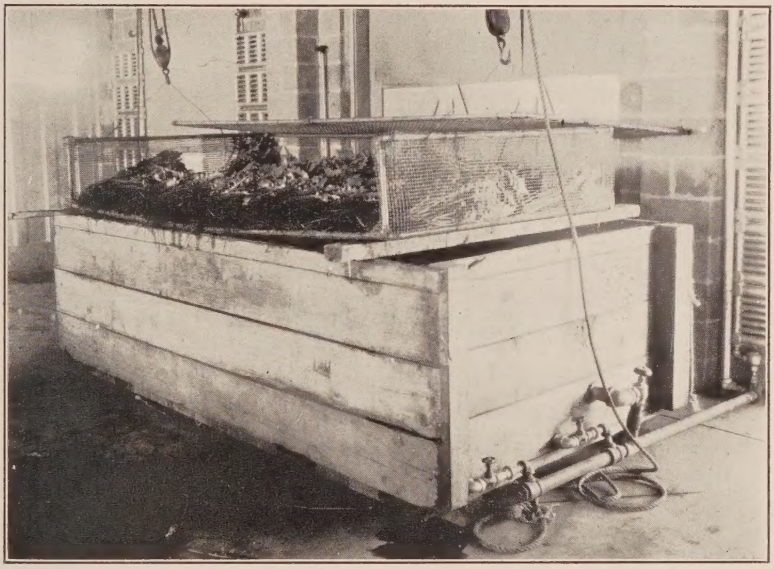

FIGURE 7.—Metal-lined tank, approximately 3½ feet deep, 6 feet wide, and 12 feet long, outside dimensions, fitted with hand-controlled steam lines and screen tray with cover, used for immersing gerbera plants.

VAPOR-HEAT TREATMENT

Control of the cyclamen mite on gerbera by vapor-heat treatment was investigated with the available equipment at Washington, D. C., and at Babylon, N. Y., and the results are given in table 1. The treatment by vapor heat requires a specially constructed apparatus that heats the air to the desired temperature by means of electricity or steam and at the same time completely saturates it with moisture. In these tests in which plants in thin layers were exposed for periods of from 5 to 60 minutes at 110° F., a treatment for 30 minutes or longer gave a complete kill of all mites. A treatment for 60 minutes is probably advisable because of even greater assurance of a complete kill since, as shown in tests with several varieties, only the most tender ones are injured even slightly by this treatment.

TABLE 1.—*Results of tests on control of the cyclamen mite on gerbera by immersion in hot water and by vapor-heat treatment, Washington, D. C., and Babylon, N. Y., 1934*

Duration of treatment at 110° F. (minutes)	Tests	Adults in test	Mortality of adults	Quiescent mites ("pupae") in test [1]	Mortality of quiescent mites	Larvae in test	Mortality of larvae	Eggs in test [1]	Mortality of eggs
	Number	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
IMMERSION IN HOT WATER									
5	1	42	0	3	0	28	0	-------	-------
10	1	59	[2] 93.2	-------	-------	9	100.0	-------	-------
15	1	135	100.0	38	100.0	37	100.0	328	100.0
20	2	169	100.0	60	100.0	96	100.0	520	100.0
30	1	134	100.0	31	100.0	25	100.0	67	100.0
EXPOSURE TO VAPOR HEAT									
5	1	49	0	-------	-------	17	0	-------	-------
10	1	76	[2] 88.1	-------	-------	21	90.5	-------	-------
15	1	122	[2] 77.8	-------	-------	37	81.0	-------	-------
20	1	110	[2] 98.2	12	100.0	31	100.0	196	100.0
30	2	198	100.0	38	100.0	62	100.0	357	100.0
40	1	204	100.0	27	100.0	62	100.0	226	100.0
60	1	108	100.0	34	100.0	62	100.0	219	100.0
Untreated checks	2	258	0	61	0	112	0	427	0

[1] The presence of eggs and "pupae" was ignored in tests where the adults or larvae survived as the surviving adults might have laid the eggs, and surviving larvae may have pupated after the treatment.
[2] Survivors were in pubescence of young leaves and in folds of others.

PLANT TOLERANCE

TOLERANCE OF GERBERAS TO HEAT TREATMENTS FOR MITE CONTROL

In preliminary tests seedling gerberas in 3- to 6-inch pots were immersed in water at 110° F. for 10, 15, 20, 25, and 30 minutes. No injury was evident on plants immersed from 10 to 20 minutes, but the injury ranged from none to severe on the foliage of plants immersed from 25 to 30 minutes. In the case of partially grown leaves (fig. 6), injury consisted in the collapse and browning of the marginal tissue along the midvein near the base, whereas younger and older leaves were uninjured. Considerable individual variation in the degree of injury occurred among these seedlings that were given similar treatments. This individual variation was shown to hold true for the five named varieties of gerbera that were made available for experimental use (table 2), but all were uninjured by a 20-minute immersion. Of these varieties the Ruby was the most tender since it was slightly injured by a 25-minute immersion and severely injured or killed by a 30- to 40-minute treatment. The more resistant varieties, Double Pink, Orange Perfection, and Vesuvius, were slightly injured by a 40-minute immersion. From observation on the tolerance of several hundred seedlings and these varieties to heat treatments in a commercial greenhouse, it would appear that the variety Ruby represents the most tender type and Vesuvius the most tolerant.

TABLE 2.—*Varietal difference among gerbera plants in their tolerance to heat treatments, Washington, D. C., and Babylon, N. Y., 1934*

IMMERSION IN HOT WATER

Duration of treatment at 110° F. (minutes)	Degree of injury to—					
	Ruby	Double Pink	Orange Perfection	Incomparable	Vesuvius	Seedling varieties
15	None	None	None		None	None.
20	do	do	do	None	do	Do.
25	Slight	do	do	do	do	None, slight.
30	Severe	do	do	Slight	do	None, slight, severe.
40	do	Slight	Slight		Slight	

EXPOSURE TO VAPOR HEAT

30	None	None	None		None
45	do	do	do		do
60	Slight	Slight	do		do
90	Severe	do	do		do
120			Slight		Slight

Tolerance of seedlings and varieties of gerbera plants to vapor-heat treatments at 110° F. indicated (table 2) that a 60-minute treatment causes slight injury to the most tender variety (Ruby) and that a 90-minute treatment caused severe injury or death to plants of that variety, whereas a 2-hour treatment causes slight injury to the two most resistant varieties (Vesuvius and Orange Perfection).

TOLERANCE OF GERBERAS TO TREATMENTS FOR CONTROL OF NEMATODES AND CERTAIN DISEASES

In cooperation with Freeman Weiss, of the Bureau of Plant Industry, United States Department of Agriculture, tests were made to determine the tolerance of gerberas to heat treatments alone for control of the root-knot nematode (*Heterodera marioni* (Cornu) Goodey), and also to heat treatments combined with chemical antiseptics to prevent dissemination of certain diseases that kill the plants at the crown. Dr. Weiss has generously made the results of these tests available for inclusion in the present paper.

In the treatments for control of nematodes one series of tests was conducted in December 1933, in which Vesuvius gerberas survived a 30-minute immersion in water at 118° F. but developed weak new growth. Injury was not increased on plants that were immersed immediately after the hot-water treatment for 10 minutes in mercuric chloride (1:1000) or formalin (1:200), but they barely survived a 20-minute immersion in the same chemicals. In another series of treatments conducted on the same variety in May 1934, the plants died in most cases, and the few survivors developed weak new growth after they had been immersed for 30 minutes at temperatures of 116°, 118°, or 120°.

In other tests with heat treatments for control of mites, antiseptic treatments were made in which chemicals were (1) added to the water bath in which the plants were immersed for control of the mites, or (2) added to cold water in which the plants were immersed for 5 minutes immediately after removal from the hot-water bath. Plants of the

variety Vesuvius or Incomparable that were immersed for 20 or 30 minutes in water at 110° F., in which was incorporated glacial acetic acid (1:200), formalin (1:200 to 1:600), or a mixture of formalin (1:400) and acetic acid (1:200), were either killed or severely injured as evidenced by the subsequent growth. Plants were apparently uninjured when treated in a bath containing acetic acid 1:400.

Following a 20-minute immersion in water at 110° F., plants of the variety Incomparable were either killed or, in most cases, were severely injured by a 2-minute dip in acetic acid (1:100 or 1:200), formalin (1:100), or mercuric chloride (1:1,000). Plants immersed in cold dips of formalin (1:200), an organic mercury compound (1:200), bordeaux mixture (4:4:50), or commercial dry lime-sulphur (1:100) were apparently little affected, judging from the ultimate growth attained.

From these tests it is apparent that gerberas cannot be safely treated for nematode control by immersion in water at 116° to 120° F., nor can they be treated with certain common antiseptic chemicals for disease control in conjunction with the hot-water treatment for mites. Acetic acid (1:400) in the hot-water bath, or cold dips following treatment, consisting of an organic mercury compound (1:200), bordeaux mixture (4:4:50), or dry lime-sulphur (1:100), were among those best tolerated by gerberas.

PROCEDURE IN TRANSPLANTING AND TREATING GERBERAS TO PREVENT REINFESTATION

Tarsonemid mites can be disseminated by brushing infested plants or plant remnants against uninfested ones, or by the hands or tools when disbudding, potting, or working among the plants. Precautions to prevent reinfestation of the plants after treatment are essential to obtain successful control.

FIGURE 8.—Vigorous new leaves growing vertically from gerbera plant crowns 10 days after hot-water treatment and replanting.

The essential procedure followed in the successful treatment of a large stock of gerbera plants including 60,000 flowering size plants and many seedlings in one range of greenhouses was as follows: All plant material was cleaned out of each house to be planted with gerberas, manure was added to the soil, and the beds were sterilized by steam through permanent lines of buried tile. A heavy application of naphthalene flakes was made on the walks, and the ventilators were closed for 1 week, or until replanting was started. In preparing the gerberas for replanting, one group of men dug, cleaned, and divided

the old plants, placed them on the large tray in the treating tank (fig. 7), lowered them into the water for treatment, and raised them from the water at the end of the treatment, to drain off the excess water. A second group of men who had not handled the infested plants, removed the plants from the tray, carried them in boxes to the greenhouse, and planted them in the beds. The men washed their hands in the hot-water tank before they handled the treated plants if it ever became necessary for them to handle the untreated ones. The foliage of treated plants was never permitted to touch the floor in the treating room, which was kept free of all litter and was frequently washed with a hose. The order in which the houses were replanted was arranged so that untreated plants were never carried through any of those being replanted or being prepared for replanting.

FIGURE 9.—View of gerberas in full flower and showing no injury by mites.

As shown in figure 8, the gerberas are planted in a reclining position with the long-stemmed leaves arranged in one direction. The old foliage is damaged less in the cultivation of the beds when the planting is done in this manner than when the old leaves are allowed to fall in any direction, as they would if the plants were set upright.

Figure 8 shows the upright new leaves appearing above the reclining old foliage 10 days after the plants were treated and replanted. The luxuriant growth and numerous flowers and buds of plants 4 months after they had been treated and planted are shown in figure 9. The methodical procedure followed in treating and transplanting the large stock of gerberas was rewarded by the apparent elimination of the cyclamen mite, and further treatments at the end of the following two flowering seasons were unnecessary.

SUMMARY AND CONCLUSIONS

Investigations have been made on the habits of the cyclamen mite, the broad mite, and several species of saprozoic tarsonemid mites occurring on gerbera plants in greenhouses.

The broad mite builds up infestations to large numbers and by feeding on the foliage causes severe dwarfing and curling of the leaves, resembling injury caused by a disease. Flowers are attacked and the rays are aborted and decolorized.

The cyclamen mite feeds on the foliage and produces bronzed patches along the midribs and slight curling of foliage. The flowers are attacked in the bud stage and the rays are deformed, the flowers being thus rendered unsalable. Although the cyclamen mite causes less conspicuous injury than the broad mite, it is responsible for greater crop losses to gerbera growers.

Among the various treatments that are effective against the broad mite, dusting the plants with sulphur appears to be the most effective.

The cyclamen mite has not been controlled by the various sprays, dusts, and fumigants applied against it on gerbera. Heat treatments, either with hot water or with vapor heat, have been found effective. Divided plants immersed for 15 to 20 minutes in water at 110° F., or treated 30 to 60 minutes in vapor heat at the same temperature, were freed of mites. Failure to secure control by the hot-water treatment as employed by some growers was found to be due to lack of uniform penetration of heat when the plants were treated in densely packed crates. This difficulty was overcome by treating the plants in a large tray on which they were placed in a thin layer.

Considerable differences in tolerance to heat treatments are apparent among varieties of gerbera. In a hot-water treatment at 110° F., the most tender varieties are injured by a 25-minute immersion, while others withstand a 40-minute immersion. In vapor-heat treatments at 110°, the tender varieties are slightly injured by a 60-minute exposure, while the resistant ones may be treated 120 minutes with only slight injury.

In tests to determine whether gerberas would withstand heat treatments for control of the root-knot nematode, the plants were killed or severely injured by 30-minute immersion in water at 116° and 120° F. Chemical dips were generally injurious to the plants when applied in conjunction with treatment for the cyclamen mite.

In practical control operations 60,000 plants were successfully treated in hot water for mite control. Precautions were taken to prevent this material from being reinfested, and no mites or mite injuries were found among these plants during the two successive growing seasons.

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